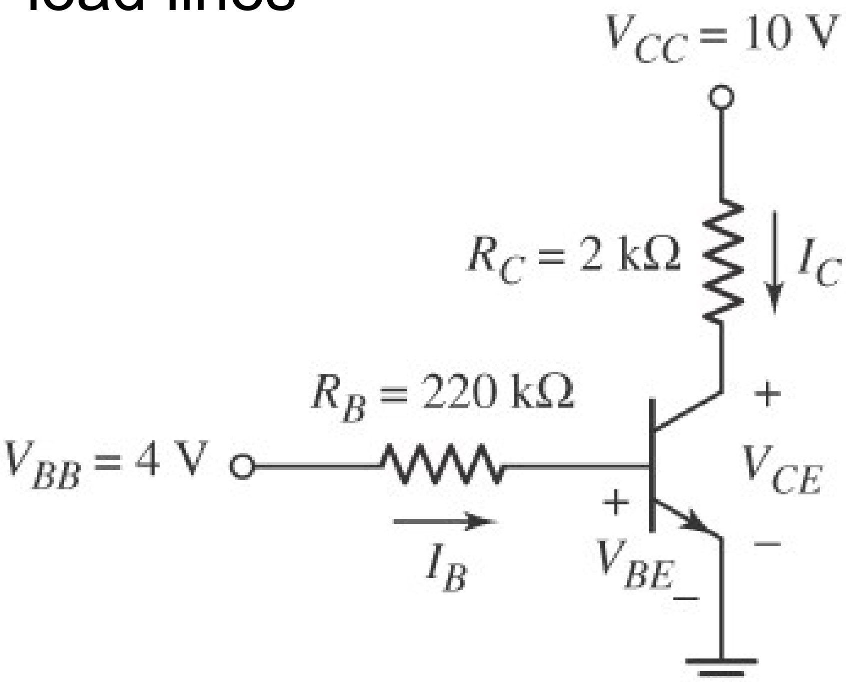
ECE 322L
Electronics 2

02/27/20- Lecture 11

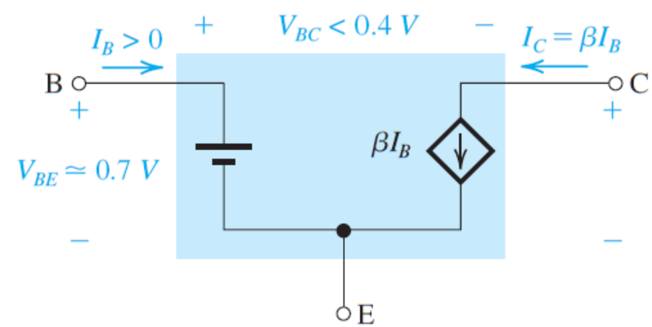
DC analysis of BJT-based circuits

In-class problem 1

The transistor parameters are V_{BE} (on) =0.7V, V_{CE}(sat)=0.2V and β=200. Calculate I_C, I_B, I_E and V_{CE}. Sketch the input and output load lines



Active
EBJ: Forward Biased
CBJ: Reverse Biased



Assume the BJT is in active mode.

$$V_{CE} > V_{CE}(\text{sat})\ V_{BE} = V_{BE}(\text{on}),\ I_B > 0, \text{ and } I_C = \beta I_B$$

In class-Problem 1-Solution

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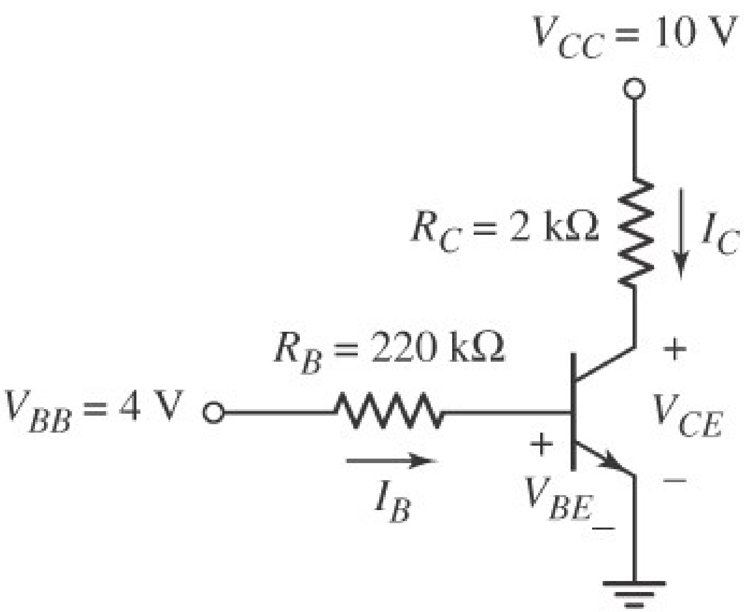

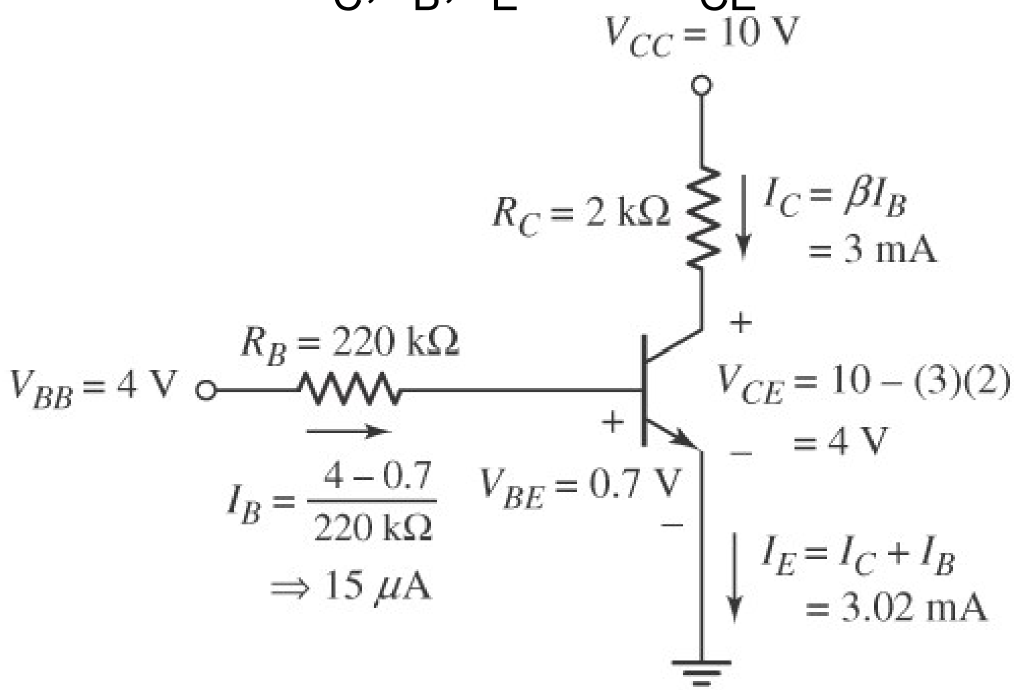

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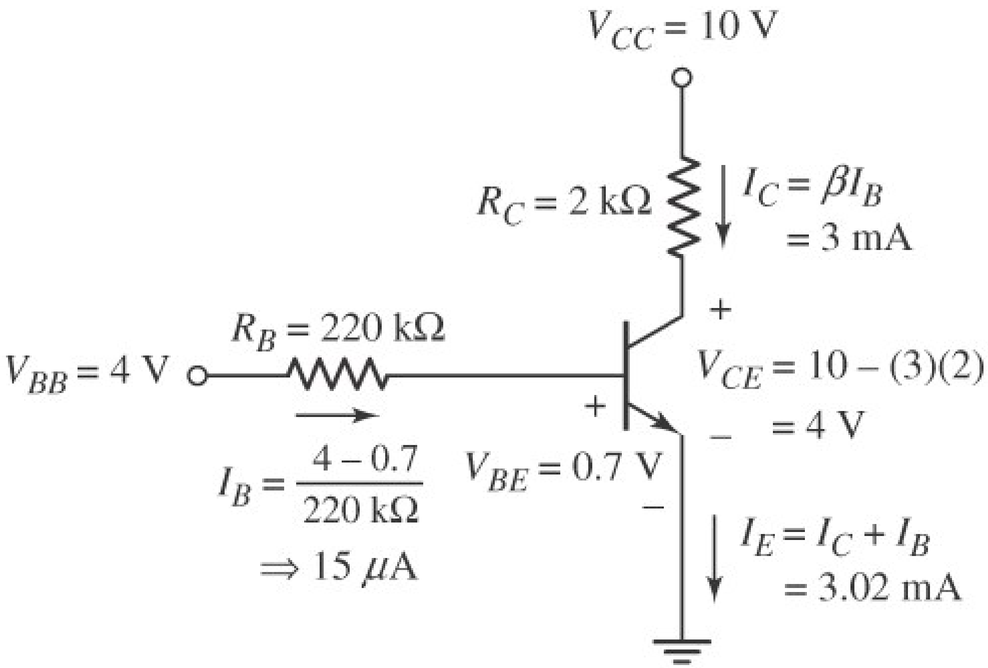
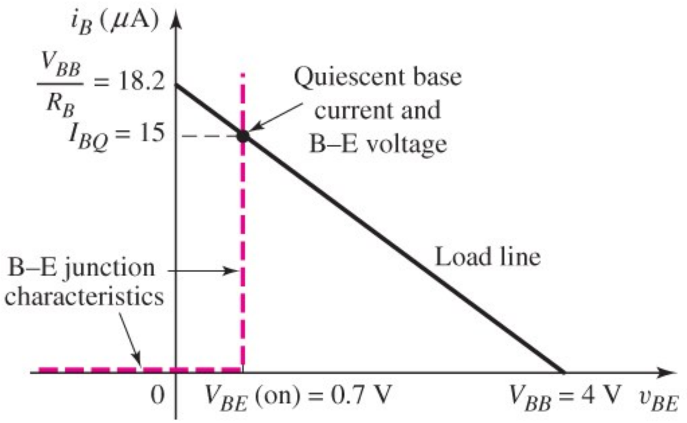
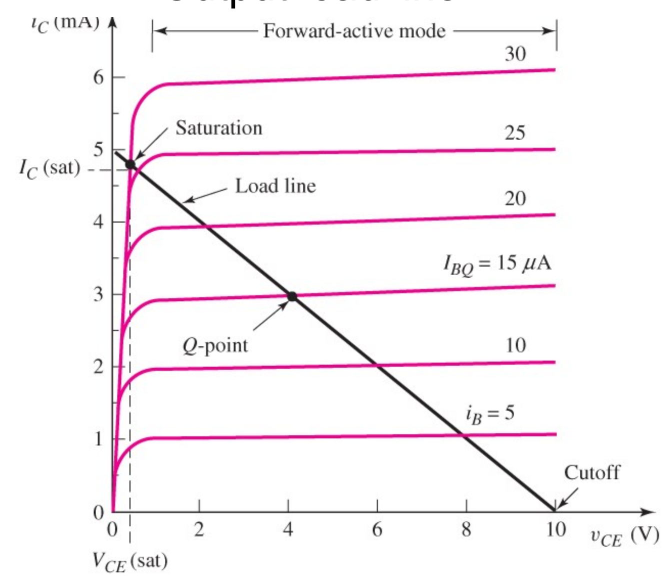
In class-Problem1-Solution



Input load line

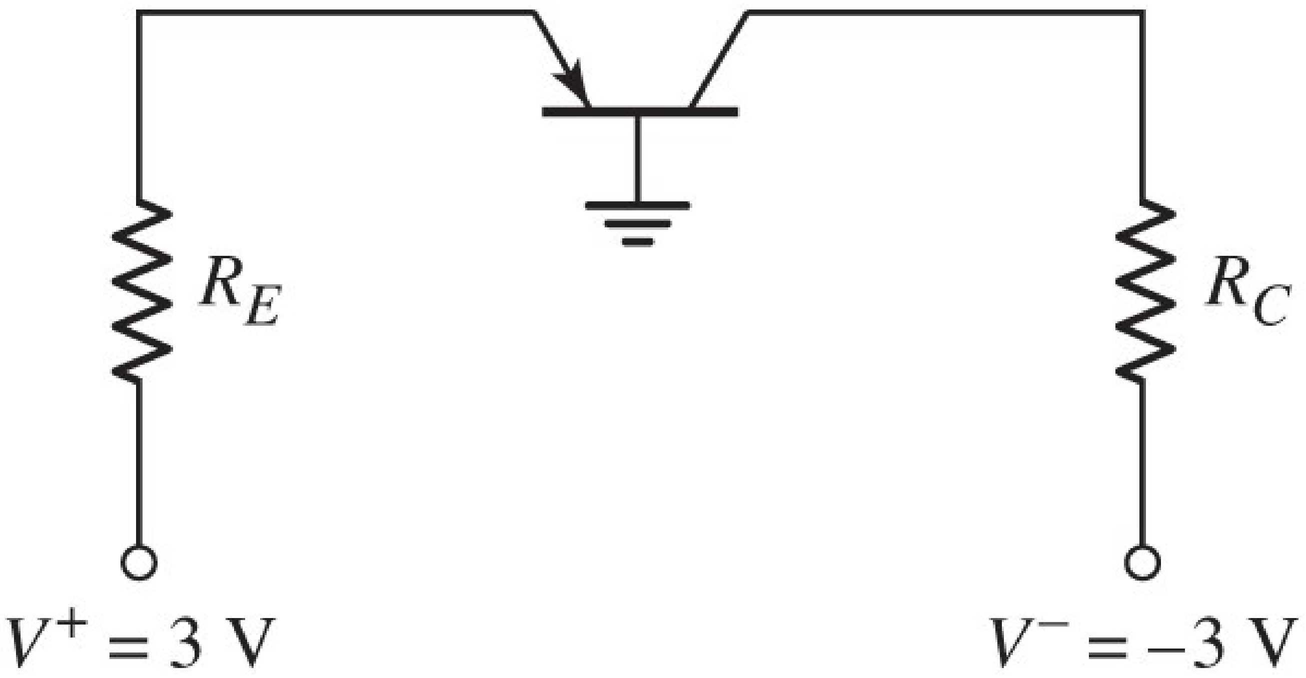


Output load line



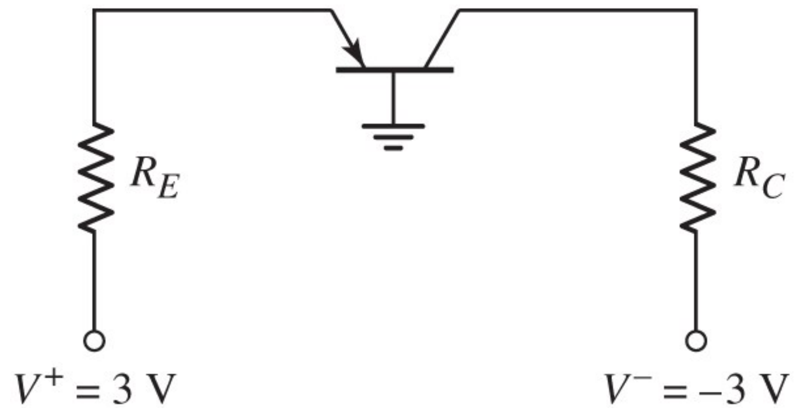
In-class problem 2

Consider the circuit below. Find the value of R_E and R_C such that I_{EQ}=0.125mA and V_{ECQ}=2.2V. The transistor parameters are β=110 and V_{EB} (on) = 0.7V. Do not assume $I_{EQ}=I_{CQ}$.



In-class problem 2, solution

Consider the circuit below. Find the value of R_E and R_C such that I_{EQ}=0.125mA and V_{ECQ}=2.2V. The transistor parameters are b=110 and V_{EB} (on) = 0.7V. Do not assume $I_{EQ}=I_{CQ}$.



$$I_{EQ} = \frac{V^+ - V_{EB}(on)}{R_E} \Rightarrow R_E = \frac{3-0.7}{0.125} = 18.4 \text{ k}\Omega$$

$$V_C = V_{EB}(on) - V_{ECQ} = 0.7 - 2.2 = -1.5 \text{ V}$$

$$I_{CQ} = \left(\frac{\beta}{1+\beta}\right) I_{EQ} = \left(\frac{110}{111}\right)(0.125) = 0.1239 \text{ mA}$$

$$R_C = \frac{V_C - V^-}{I_{CQ}} = \frac{-1.5-(-3)}{0.1239} = 12.1 \text{ k}\Omega$$

In-class problem 3

D5.40 (a) The circuit shown in Figure P5.40 is to be designed such that $I_{CQ} = 0.5$ mA and $V_{CEQ} = 2.5$ V. Assume $\beta = 120$. Sketch the load line and plot the Q-point. (b) Pick standard values of resistors that are close to the designed values. Assume that the standard resistor values vary by ± 10 percent. Plot the load lines and Q-point values for the maximum and minimum values of R_B and R_C values (four Q-point values).

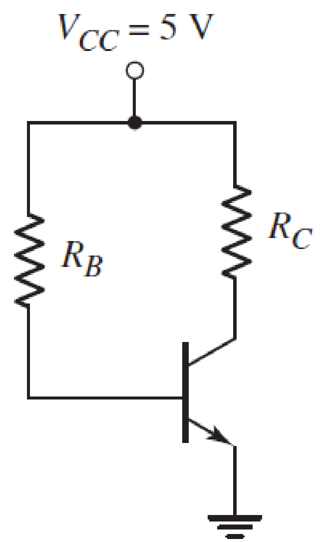
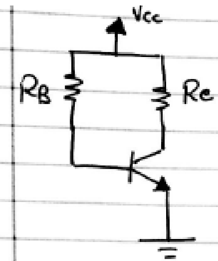


Figure P5.40

https://www.daycounter.com/Calculators/Standard-Resistor-Value-Calculator.phtml

In-class problem 3, solution



$I_{CQ} = 0.5\,mA$ $\quad V_{CEQ} = 2.5V$

$\beta = 120$

$V_{CC} = 5V$

$V_{CEQ} > V_{CE,SAT}$

(a) KVL @ the output loop: $V_{CC} - R_C I_{CQ} - V_{CEQ} = 0$

$R_C = \dfrac{5 - 2.5}{0.5m} = 5K \Rightarrow R_C = 5.1\,k\Omega$

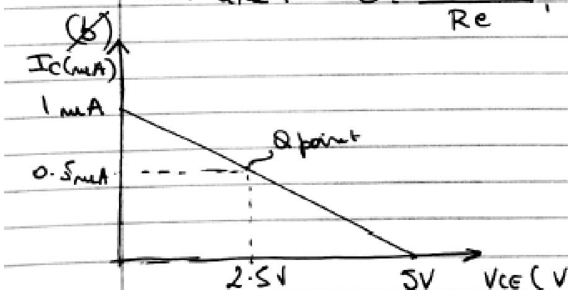
$I_{BQ} = \dfrac{0.5}{120} = 0.00417\,mA = 4.17\,\mu A$

KVL @ the input loop: $V_{CC} - R_B I_B - V_{BE(on)} = 0$

$R_B = \dfrac{5 - 0.7}{0.00417m} = 1032\,K\Omega \Rightarrow R_B = 1\,M\Omega$

Load line: $I_C = \dfrac{V_{CC} - V_{CE}}{R_C}$; $V_{CE} = 0 \Rightarrow I_C = \dfrac{V_{CC}}{R_C}$, $I_C = 0 \Rightarrow V_{CE} = V_{CC}$

(b)



(b) The two new load lines can be easily sketched considering that the point for $I_C = 0$ will remain at $V_{CE} = V_{CC}$ in both cases. On the other hand the other extreme of the load line will move to

In-class problem 3, solution

$$\frac{V_{CC}}{R_C + 0.1R_C} = \frac{5}{5.61k} = 0.891\ \mu A$$

$$\frac{V_{CC}}{R_C - 0.1R_C} = \frac{5}{4.59k} = 1.09\ \mu A$$

Case 1: $R_B + 10\%$ $R_C + 10\%$

$R_B = 1M\ (1.1) = 1.1\ M\Omega$ $R_C = 5.61\ k\Omega$

$I_{BQ} = \frac{5 - 0.7}{1.1M} = 3.91\ \mu A \Rightarrow I_{CQ} = \beta I_{BQ} = 0.469\ mA$

$V_{CEQ} = V_{CC} - R_C I_{CQ} = 5 - 5.61k \cdot 0.469m = 2.37V$

Case 2: $R_B - 10\%$ $R_C + 10\%$

$R_B = 1.0M\ (0.9) = 0.9M\Omega$ $R_C = 5.61\ k\Omega$

$I_{BQ} = \frac{5 - 0.7}{0.9} = 4.78\ \mu A \Rightarrow I_{CQ} = \beta I_{BQ} = 0.573\ mA$

$V_{CEQ} = V_{CC} - R_C I_{CQ} = 5 - 5.61k \cdot 0.573m = 1.78V$

Case 3 $R_B + 10\%$ $R_C - 10\%$

$R_B = 1.1\ M\Omega$ $R_C = 4.59k\Omega$

$I_{BQ} = 3.91\ \mu A$ $I_{CQ} = 0.469\ mA$

$V_{CEQ} = 5 - 4.59k \cdot 0.469m = 2.85V$

Case 4 $R_B - 10\%$ $R_C - 10\%$

$R_B = 0.9M\Omega$ $R_C = 4.59\ k\Omega$

$I_{BQ} = 4.78\ \mu A \Rightarrow I_{CQ} = 0.573\ mA$

$V_{CEQ} = 2.37\ V$

In-class problem 3, solution